State-Scale Statistically-Valid Survey Monitoring in South Carolina

D H E C

PROMOTE PROTECT PROSPER

South Carolina Department of Health and Environmental Control

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SC Basic Scales of Ambient Surface Water Monitoring are:

❖ **Big Picture:**

– Make state-scale statements about representative WQ [§305(b)]

❖ **Site Specific**

– Fixed Sites

– Examine long-term trends in concentration of specific WQ parameters

– Identify waterbodies not meeting classified uses [§303(d)]

– Track specific targeted activities

State-Scale Statistically-Valid Surveys

Why?

What Do SCDHEC Fixed-Sites Represent?

❖ Pour Point of pre-defined watershed boundaries

❖ Under the fixed-site monitoring design, larger streams dominate the conditions sampled

❖ The smaller order streams are not proportionally represented

❖ Fixed sites could at best only represent a small portion of the total resource

Difference in What is Represented

❖ The statistical survey component, like an election poll or phone survey, represents an estimate of the condition of the entire resource

❖ Under the survey design all stream sizes are included and proportionally represented in the results

SC Statistical Survey Component

❖ Began 2001, before NARS, in the days of EMAP

❖ Survey Sites Sampled monthly for 1 year

❖ Make comprehensive statements about state-scale WQ conditions **(§305(b) use support)**

- "Unbiased random sample" of water resources (like a phone survey or election poll)
- Represents entire resource **("All Waters")**
- Known confidence of condition estimates

❖ Sample previously unsampled locations

- Apply assessment methodology to identify new §303(d) candidates

How?

Generalized Random Tessellation Stratified (GRTS) Survey Design

EPA Aquatic Resources Monitoring – General Overview of Probabilistic Surveys

❖ Probability sample producing design-based estimators and variance estimators

❖ Gives another option to simple random sample and systematic sample designs

❖ Emphasize spatial-balance
  - Every replication of the sample exhibits a spatial density pattern that closely mimics that of the resource

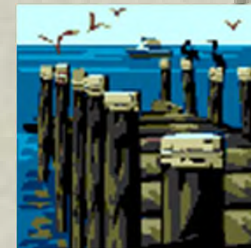# Resource Types Assessed Using Statistical Survey Approach

❖ **Streams**

❖ **Lakes**

❖ **Estuaries**

# Statistical Magic

❖ It requires around 50 to 60 sites to make a population statement around ± 10% with 90% confidence

❖ We sample 30 sites per year in each resource type

❖ Currently we compile 5 years of data for each resource type to make a statewide statement around ± 6% with 95% confidence

Streams – Aquatic Life Use Fully Supported Confidence Estimates Rolling 2 Year vs. 5 Years
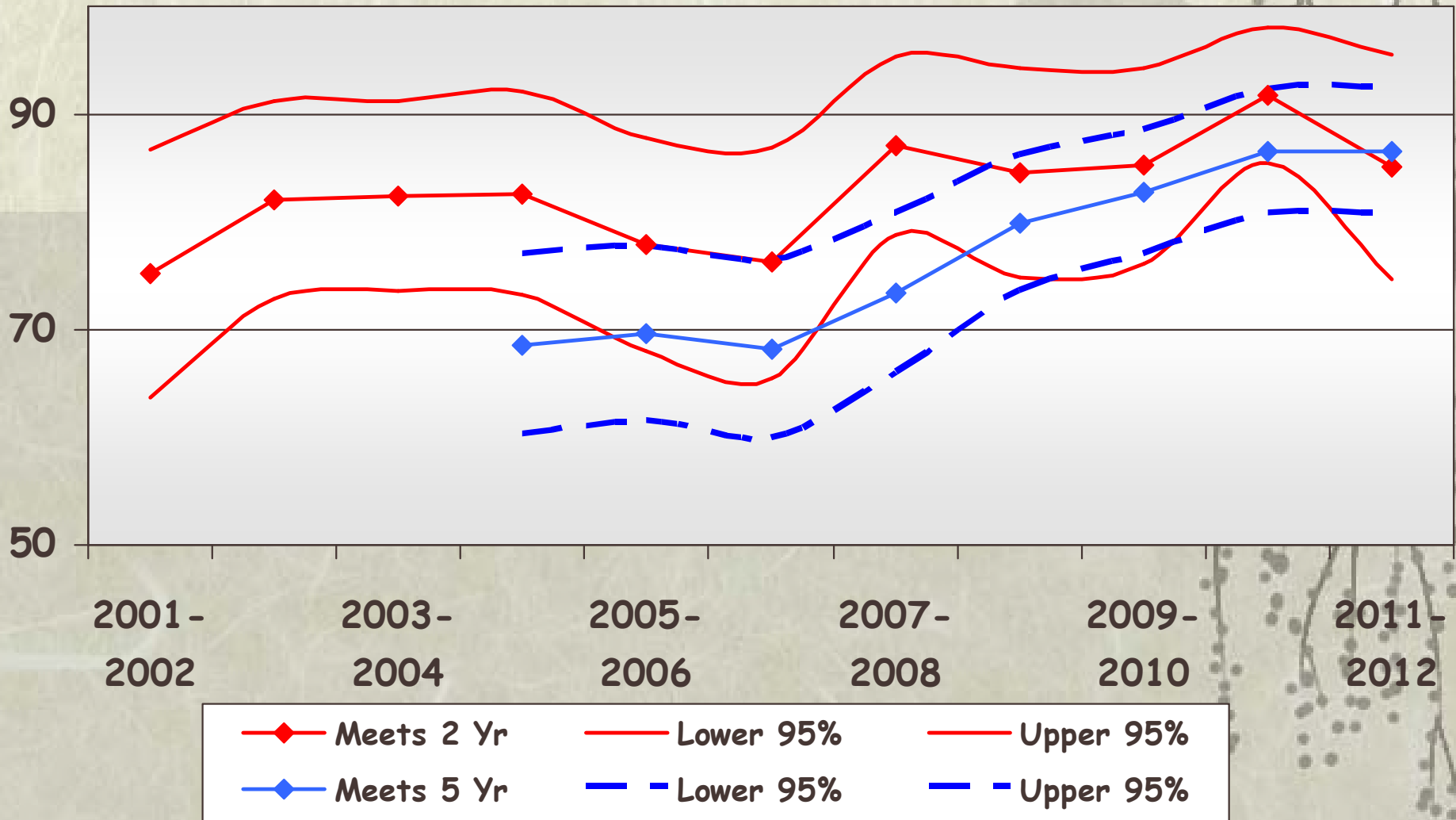
We Use R©

❖ To select sites for all waterbody types
❖ Analyze the resulting data

Important Considerations

❖ It is necessary to keep track of every selected site that can't be sampled and why because it affects the estimate of the total resource size

– Target Population
  • No acceptable access
  • Physical barrier or dangerous conditions

– Non-Target (sample frame errors – GIS layer wrong)
  • No stream present
  • Intermittent, no flow
  • Impoundment or immediate outflow
  • Saltwater

Significant Assumption

❖ Does water quality at inaccessible sites vary similarly to that at accessible sites?

 – i.e. does water quality vary randomly across inaccessible and sampled sites?

❖ If so, then it can be assumed that results from the sampled sites still accurately reflect the condition of the resource

❖ And therefore represent "all waters" of the total resource

So what do the statewide statistical survey results show?
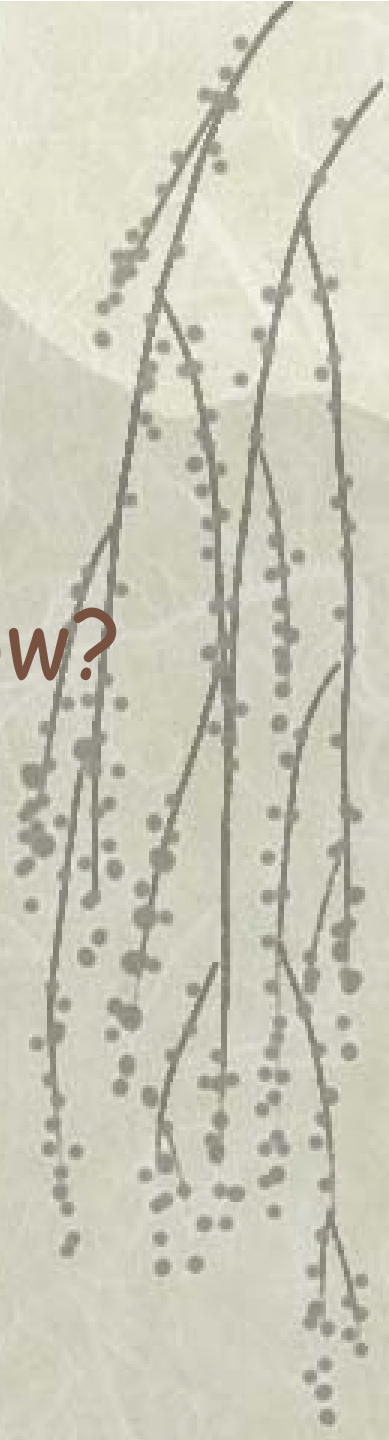
Aquatic Life Use Support

❖ Degree to which water quality supports a balanced aquatic community

❖ ~CWA "Fishable"

Dissolved Oxygen	pH
Metals	Ammonia
Macroinvertebrate	Turbidity
Community (wadeable streams)	
Nutrients (lakes)	Chlorophyll-a (lakes)

Recreational Use Support

❖ Degree to which water quality supports recreational activities in and on the water

❖ ~CWA "Swimmable"

Fecal Coliform Bacteria*

Enterococci*

*Escherichia coli**

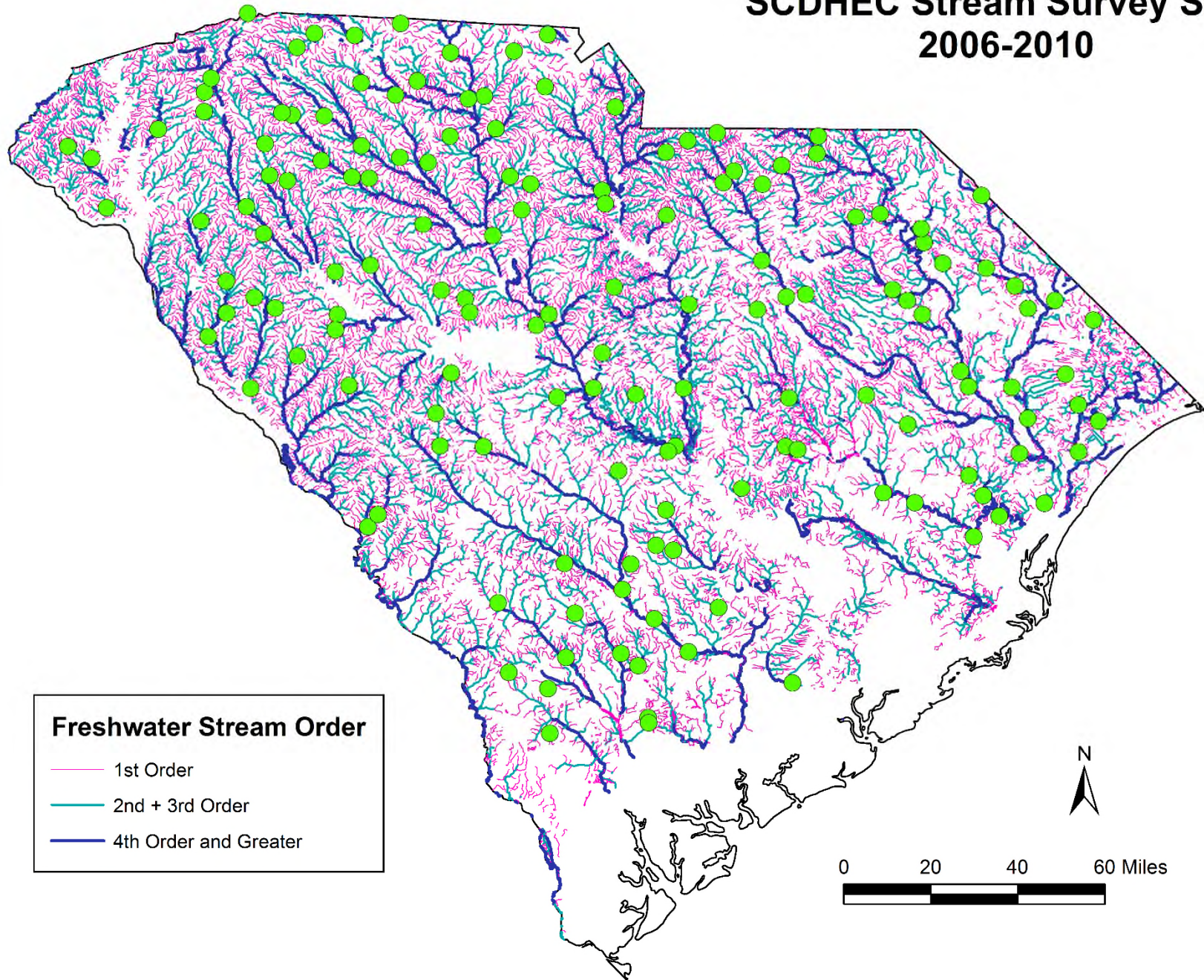# Targeted Categories for Statistical Survey Sites

❖ **Streams**

❖ 30 sites sampled monthly

 – 8 first order streams

 – 10 second & third order streams

 – 12 fourth order & greater streams

❖ Unequal weights

SCDHEC Stream Survey Sites 2006-2010

Freshwater Stream Order

— 1st Order

— 2nd + 3rd Order

— 4th Order and Greater

N

0   20   40   60 Miles

Rivers & Streams

❖ **Statistical Survey Results**

– 148-150 water quality monitoring sites per 5-Year assessment period

– Estimated 19,846-25,261 miles of streams between 5-Year assessment periods

Assessment Period	N Sites	Estimated Resource Size (Miles)
2001_2005	148	19,846
2002_2006	149	21,367
2003_2007	150	23,303
2004_2008	149	22,417
2005_2009	149	22,784
2006_2010	149	24,749
2007-2011	149	25,261
2008-2012	149	24,436

Streams –Aquatic Life Use
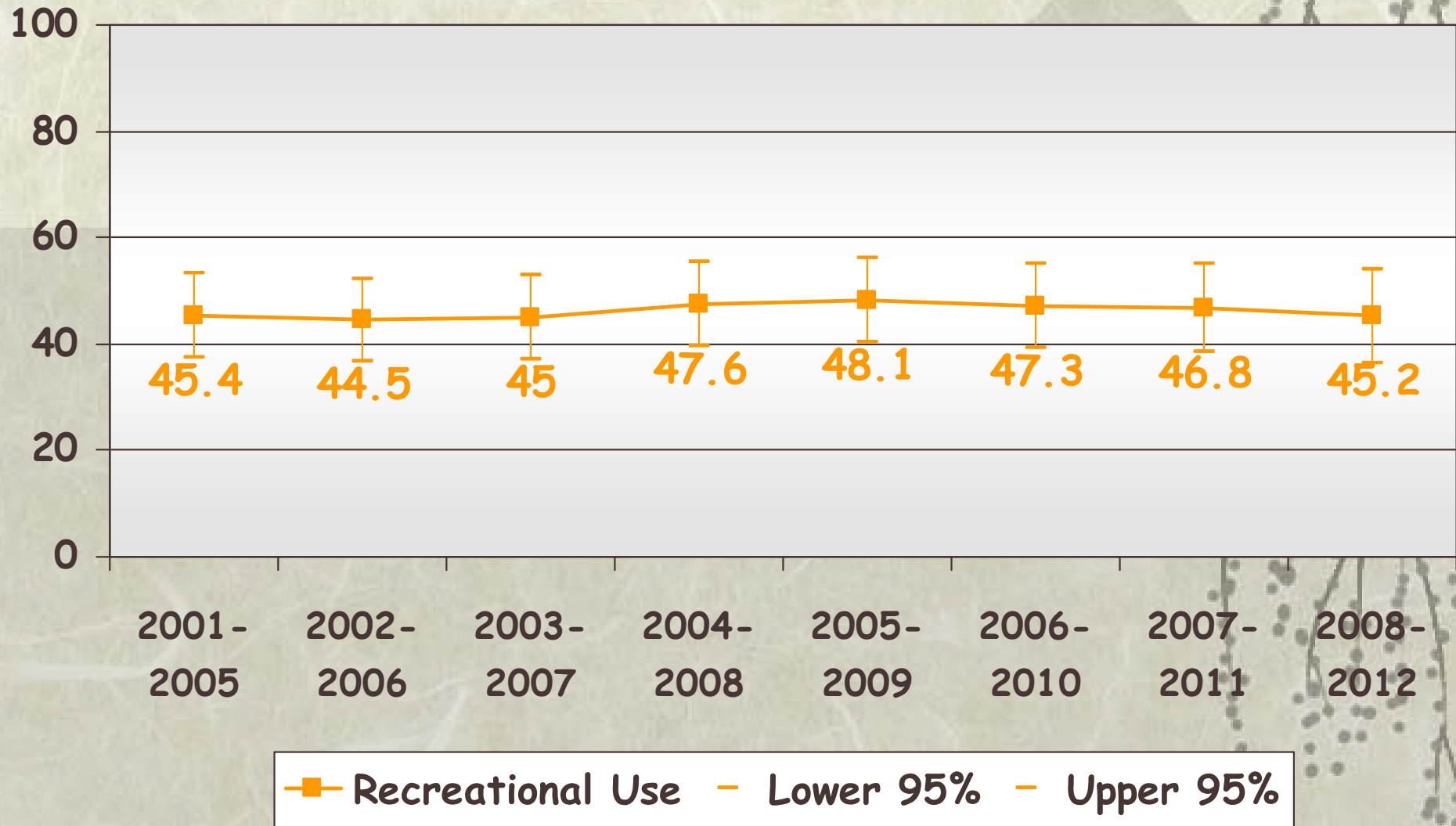## Fully Supporting - §305(b) 5 Years
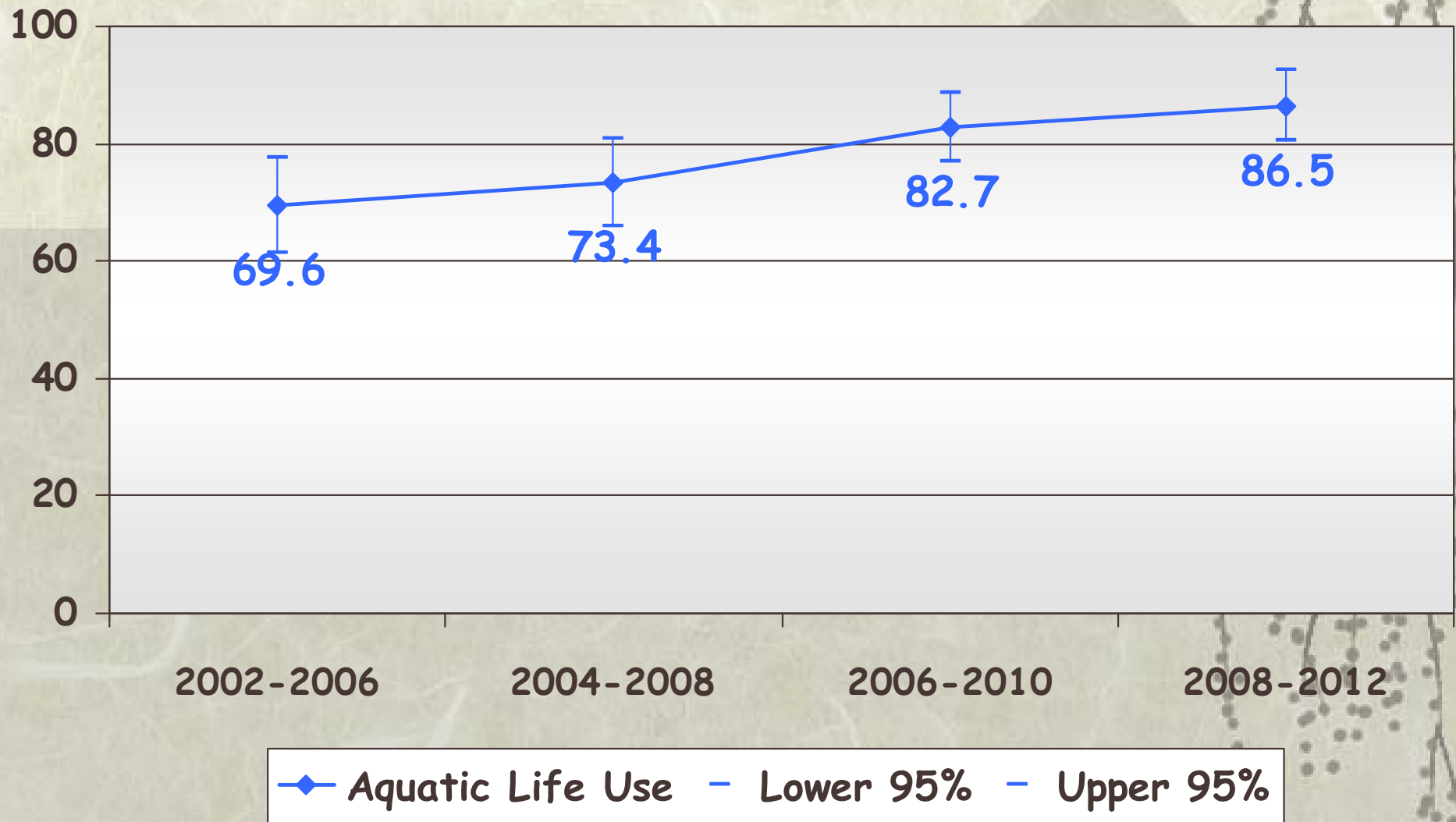
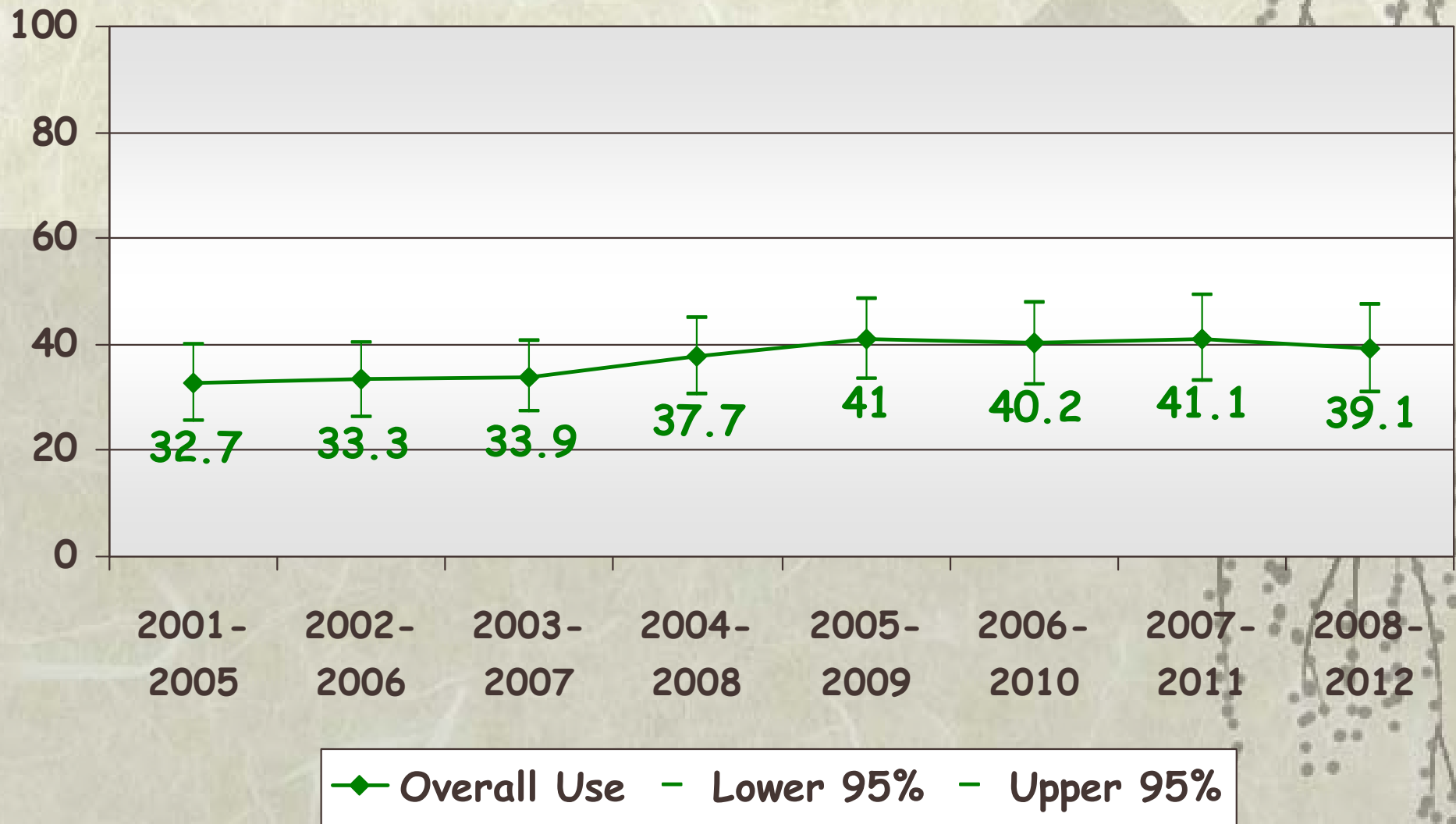Streams – Aquatic Life Use
Fully Supporting - Rolling 5 Years
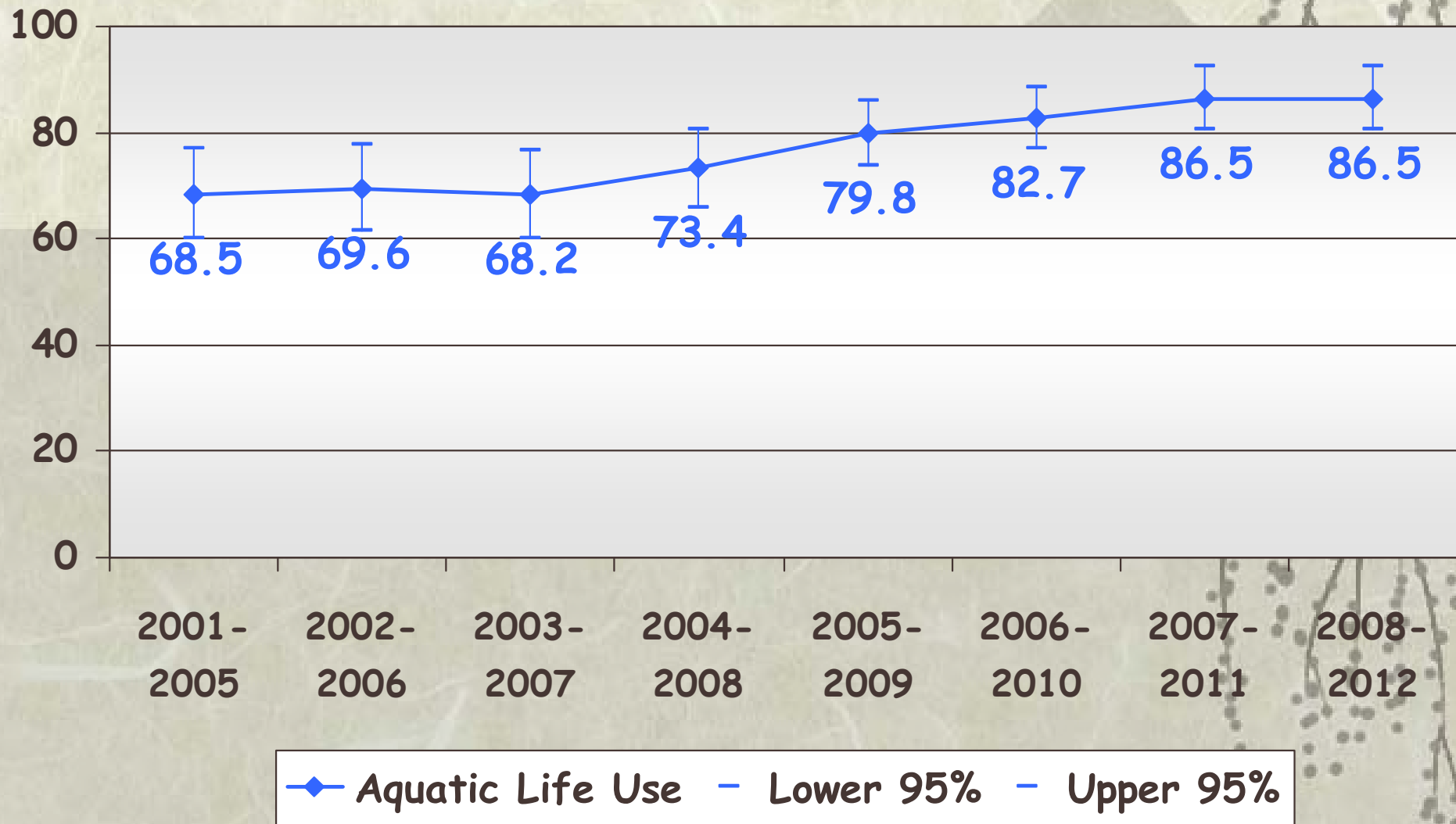
Streams – Recreational Use
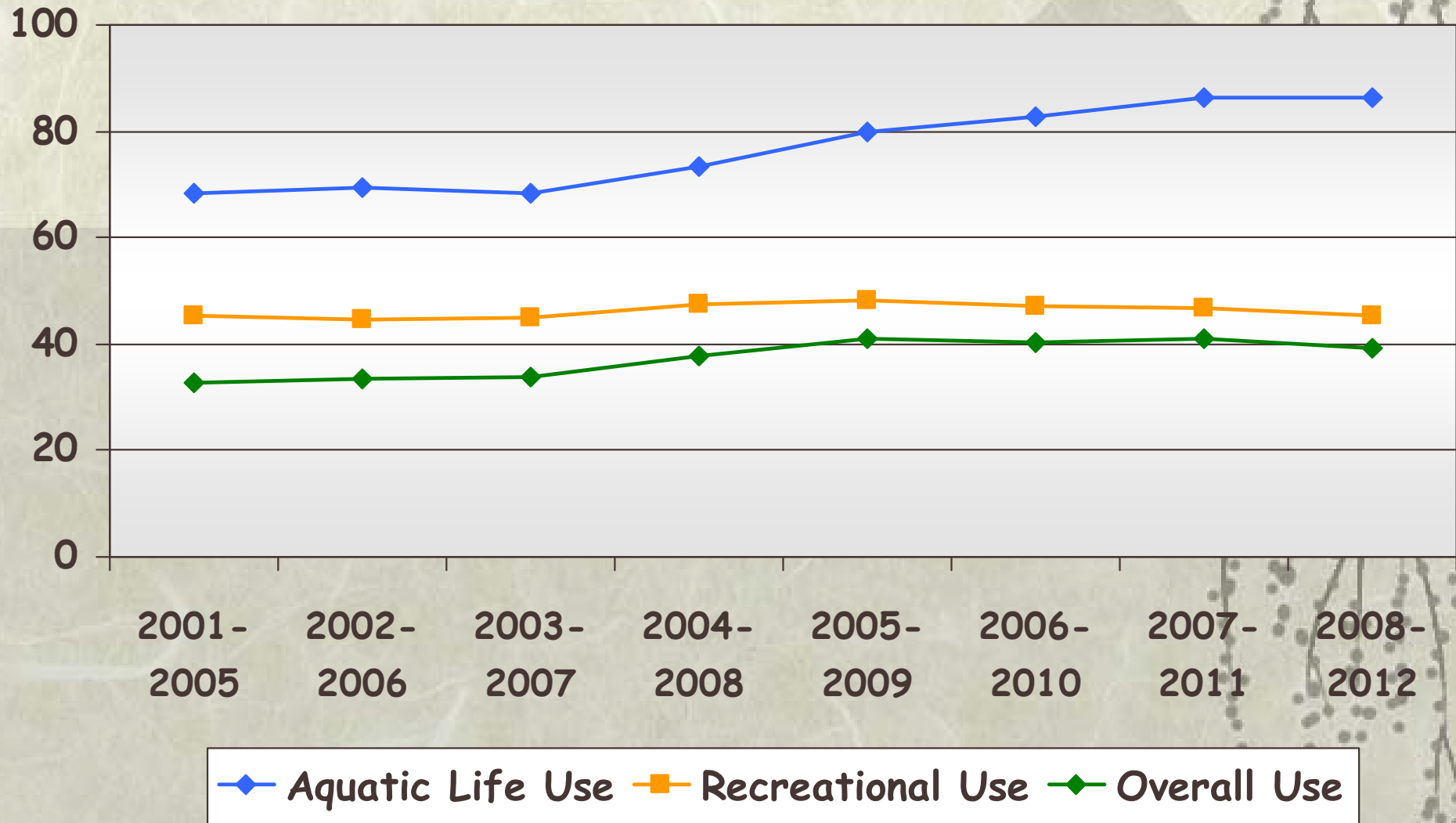## Fully Supporting - Rolling 5 Years

Streams – Overall Use
Fully Supporting - Rolling 5 Years

Streams – Summary
Fully Supporting - Rolling 5 Years

Legend: Aquatic Life Use, Recreational Use, Overall Use

# Streams - Top Causes of Aquatic Life Use Impairment

❖ 2001-05, 02-06, 03-07, 04-08, and 05-09
   1. Macroinvertebrates* (4.6-21.7% of total resource)
   2. Dissolved Oxygen
   3. - 5. pH, Zinc, Turbidity jockeying for position

❖ 2006-10, 07-11, 08-12, DO and Macro switched position

❖ *Macroinvertebrates not sampled at ~61% – 86% of the total resource, depending on period

Macroinvertebrate Community Assessment Results

Assessment Period	Meets		Impaired		Not Assessed	
	N Sites	Estimated Percent	N Sites	Estimated Percent	N Sites	Estimated Percent
2001_2005	25	17.9	23	21.3	98	60.8
2002_2006	22	15.8	26	21.7	101	62.5
2003_2007	19	13.6	25	21.5	106	64.9
2004_2008	13	9.2	21	15.3	115	75.6
2005_2009	14	11.2	16	9.8	119	79.1
2006_2010	9	7.6	13	6.9	127	85.4
2007_2011	9	8.9	6.0	4.6	134	86.5
2008-2012	7	9.6	6.0	5.9	136	84.7

Streams – Aquatic Life Use
Fully Supporting - Rolling 5 Years
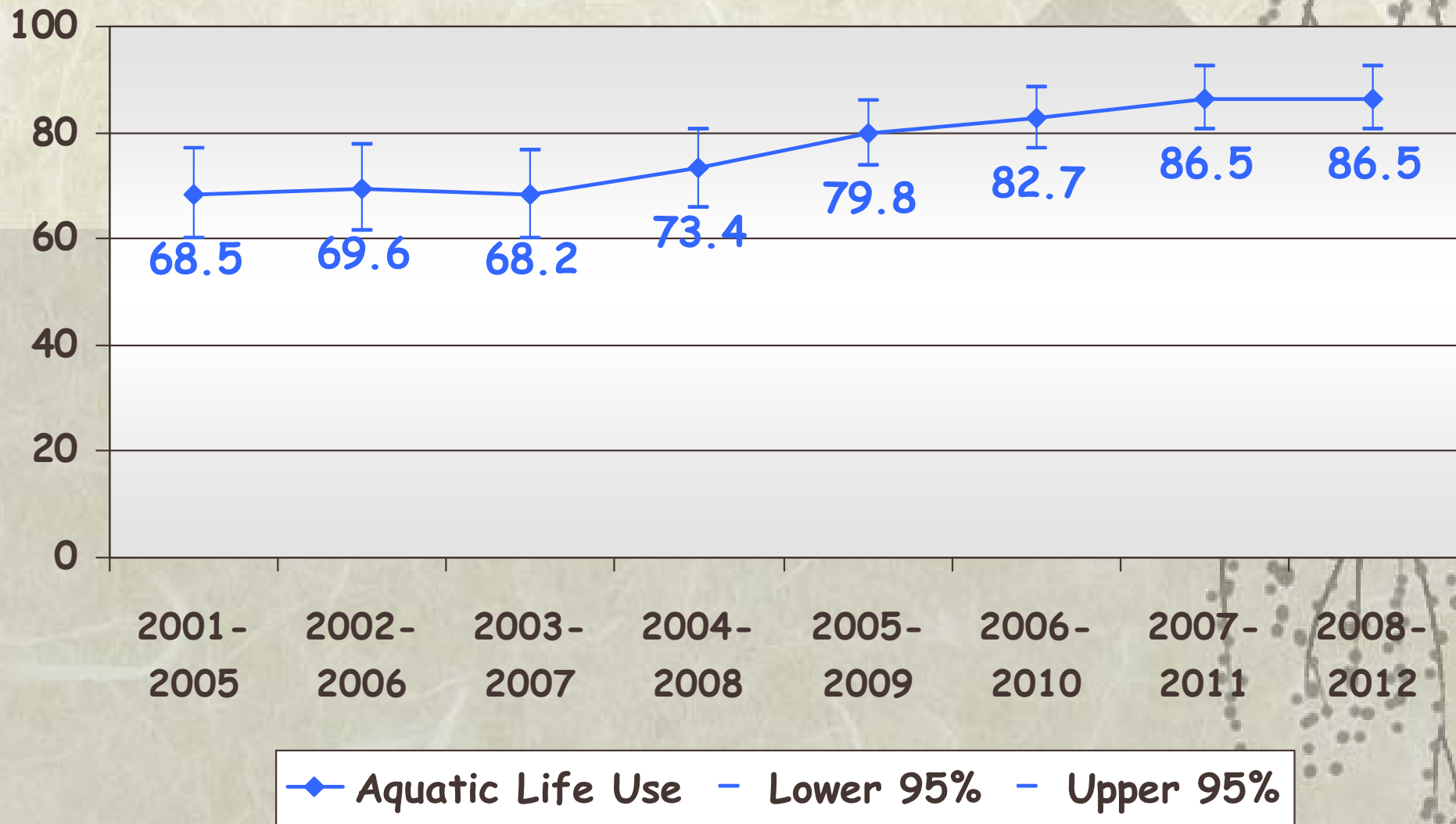
Targeted Categories for Statistical Survey Sites

❖ **Significant Lakes with Public Access:**

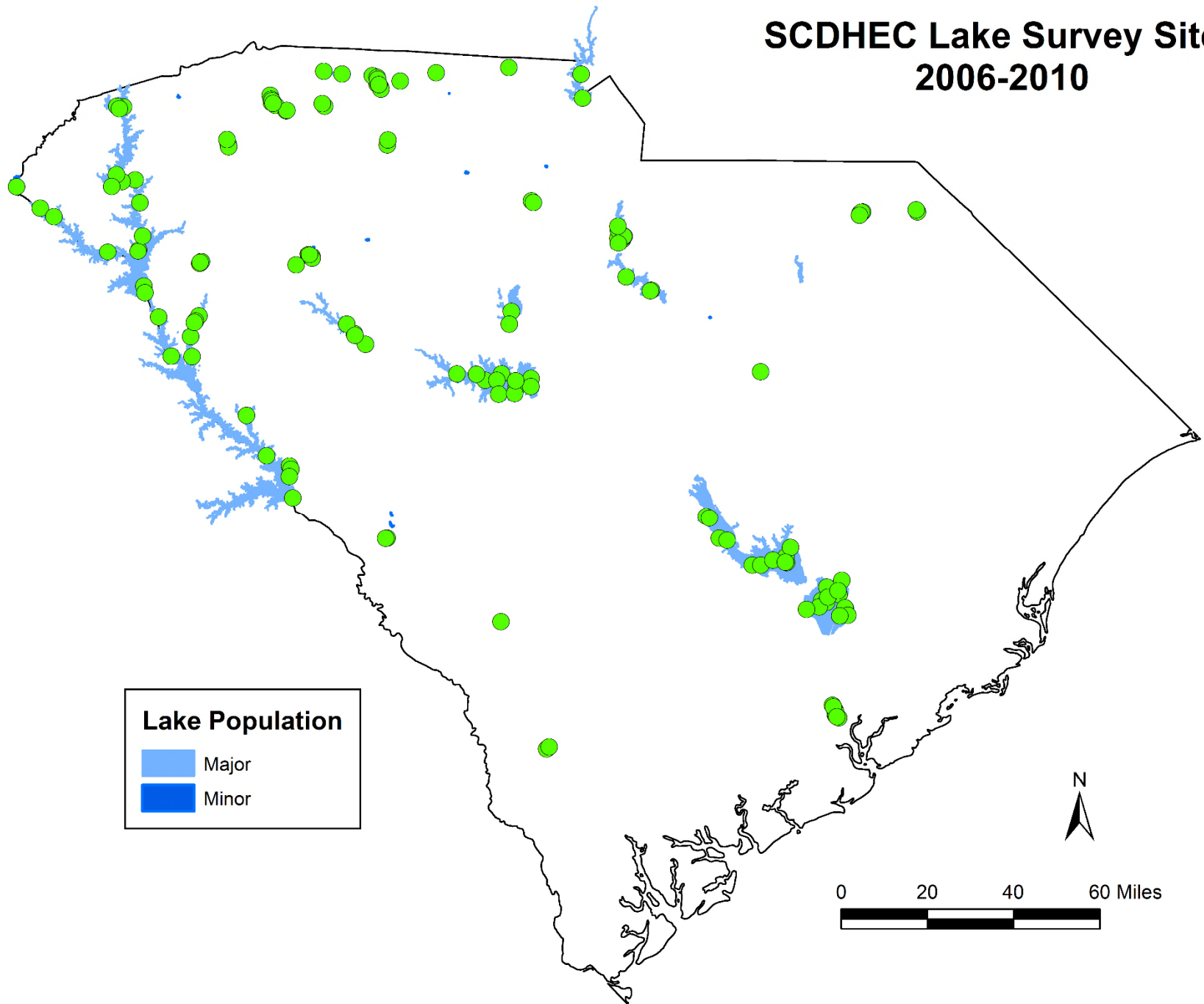- 17 Major Lakes ($\geq$ 850 acres)
- 15 Minor Lakes (40 to 850 acres)

❖ 30 sites sampled monthly

  – 20 in Major lakes

  – 10 in Minor lakes

❖ Unequal weights

SCDHEC Lake Survey Sites
2006-2010

Lake Population

Major

Minor

N

0   20   40   60 Miles

Lakes & Reservoirs

❖**Statistical Survey Results**

– 125 - 139 water quality monitoring sites per 5-Year assessment period

– Estimated 389,336-395,413 acres of lake/reservoir between 5-Year assessment periods

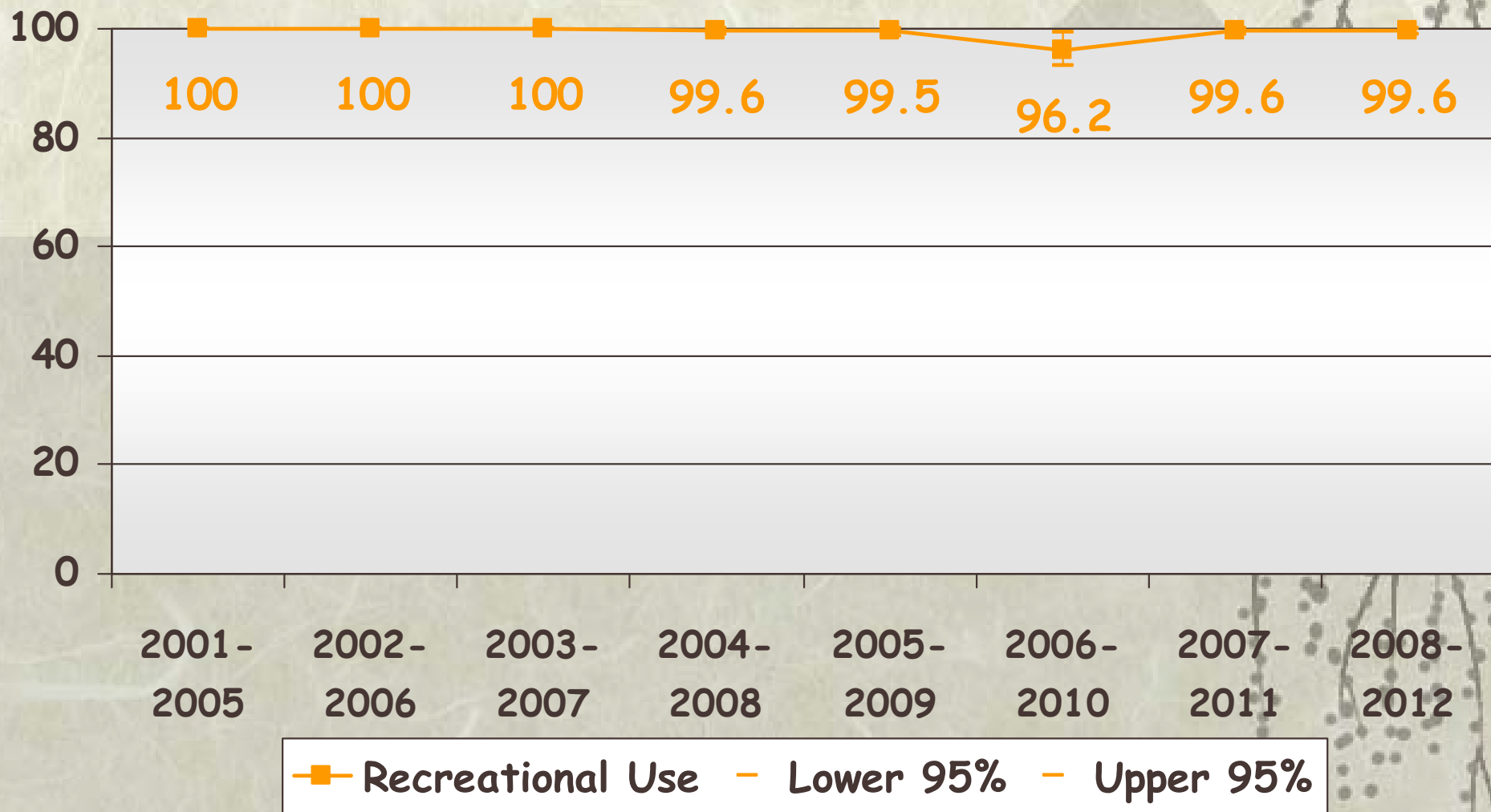| Assessment Period	N Sites	Estimated Resource Size (Acres)
2001-2005	128	389,778
2002-2006	128	389,336
2003-2007	130	393,389
2004-2008	127	390,579
2005-2009	125	395,413
2006-2010	132	393,430
2007-2011	136	393,430
2008-2012	139	393,430

Lakes – Aquatic Life Use
Fully Supporting - Rolling 5 Years
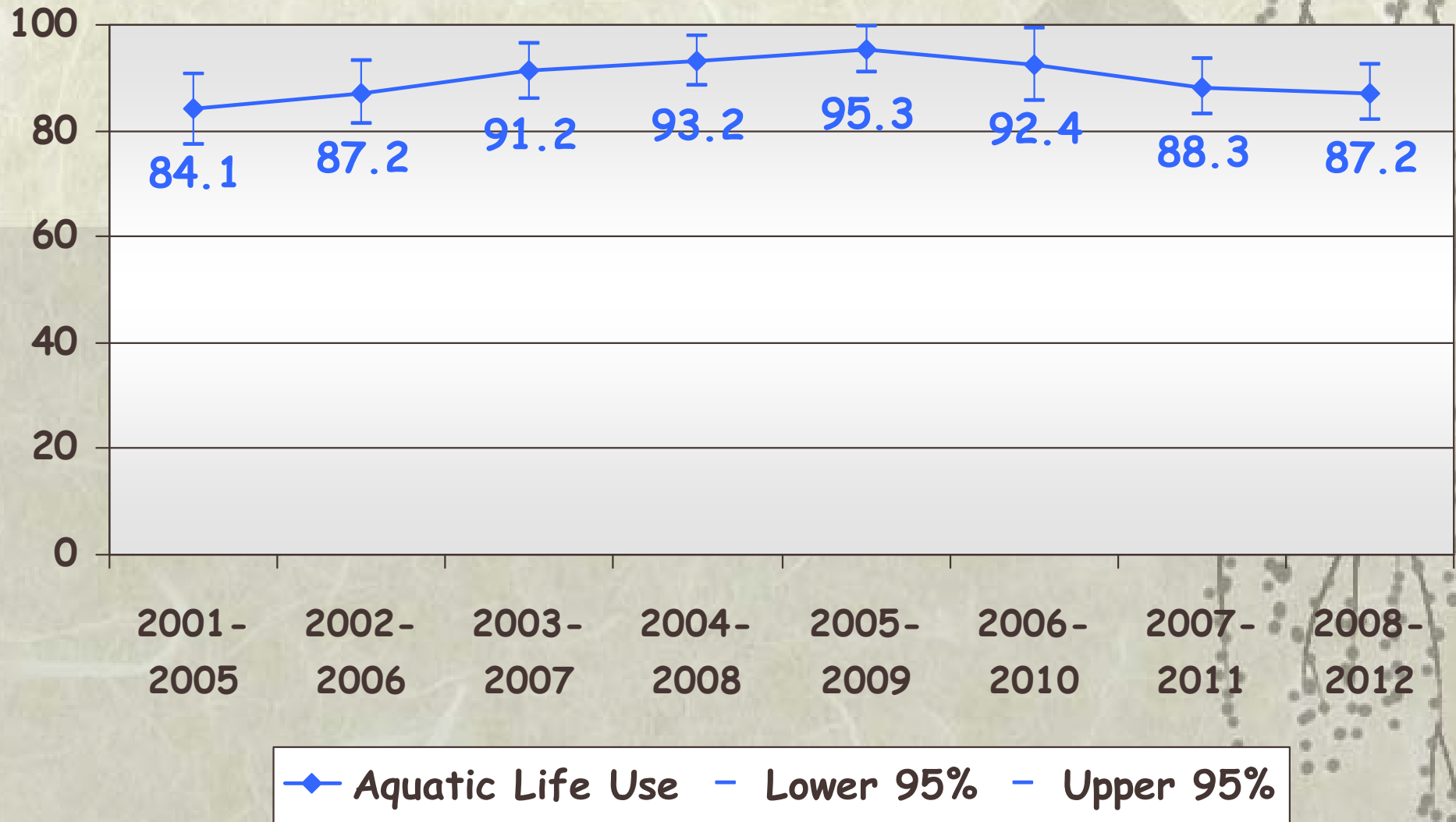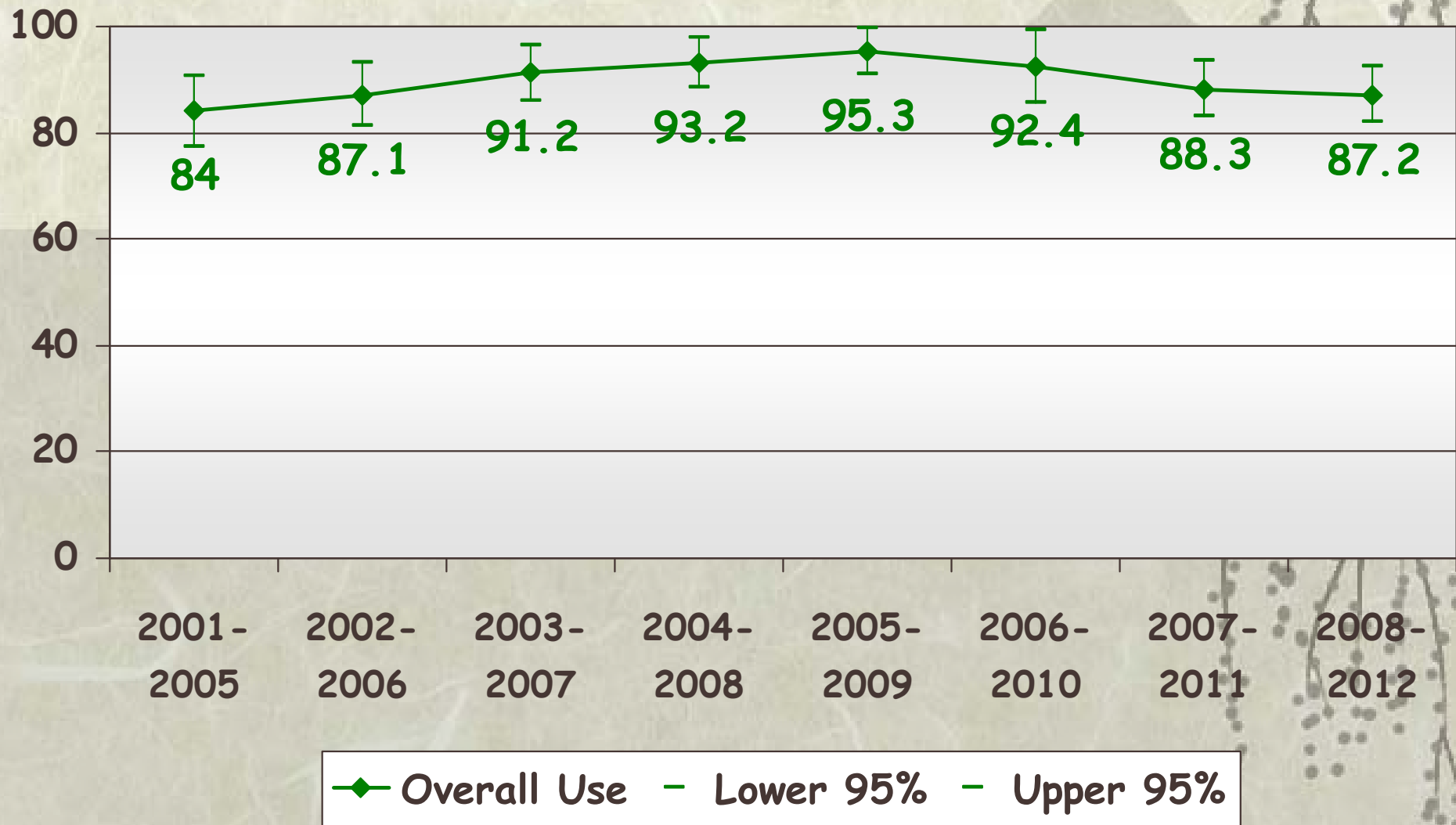
Lakes – Recreational Use
Fully Supporting - Rolling 5 Years

Note: No fecal coliform data were collected at 1 site in 2008 and 4 sites in 2010. This represents area Not Assessed, not Impaired.

Lakes – Overall Use
Fully Supporting - Rolling 5 Years

Chart showing Overall Use values by rolling 5-year period:
- 2001-2005: 84
- 2002-2006: 87.1
- 2003-2007: 91.2
- 2004-2008: 93.2
- 2005-2009: 95.3
- 2006-2010: 92.4
- 2007-2011: 88.3
- 2008-2012: 87.2

Legend: Overall Use — Lower 95% — Upper 95%

Lakes – Summary
Fully Supporting - Rolling 5 Years

Chart legend: Aquatic Life Use, Recreational Use, Overall Use
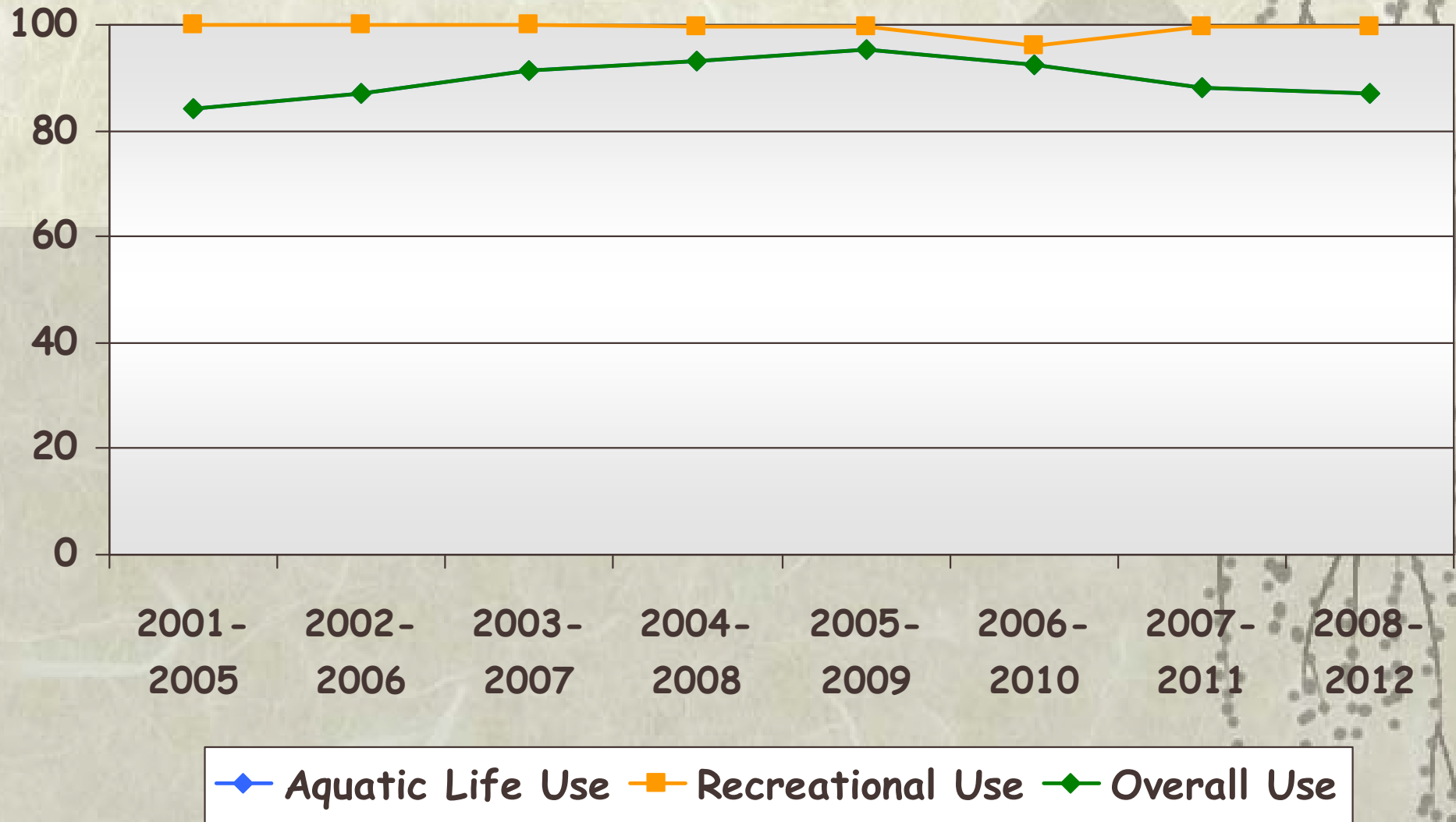
Lakes - Top Causes of Aquatic Life Use Impairment

❖ Positions 1 and 2 varied between pH and Total Phosphorus for all assessment periods

❖ Positions 3, 4, and 5 varied between Dissolved Oxygen, Turbidity, Total Nitrogen, Chlorophyll-*a*

❖ Copper and Ammonia each made the top 5 at least once

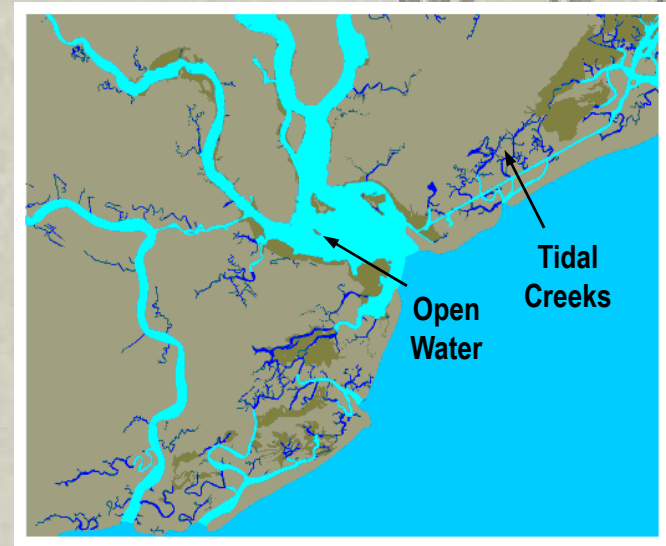# Targeted Categories for Statistical Survey Sites
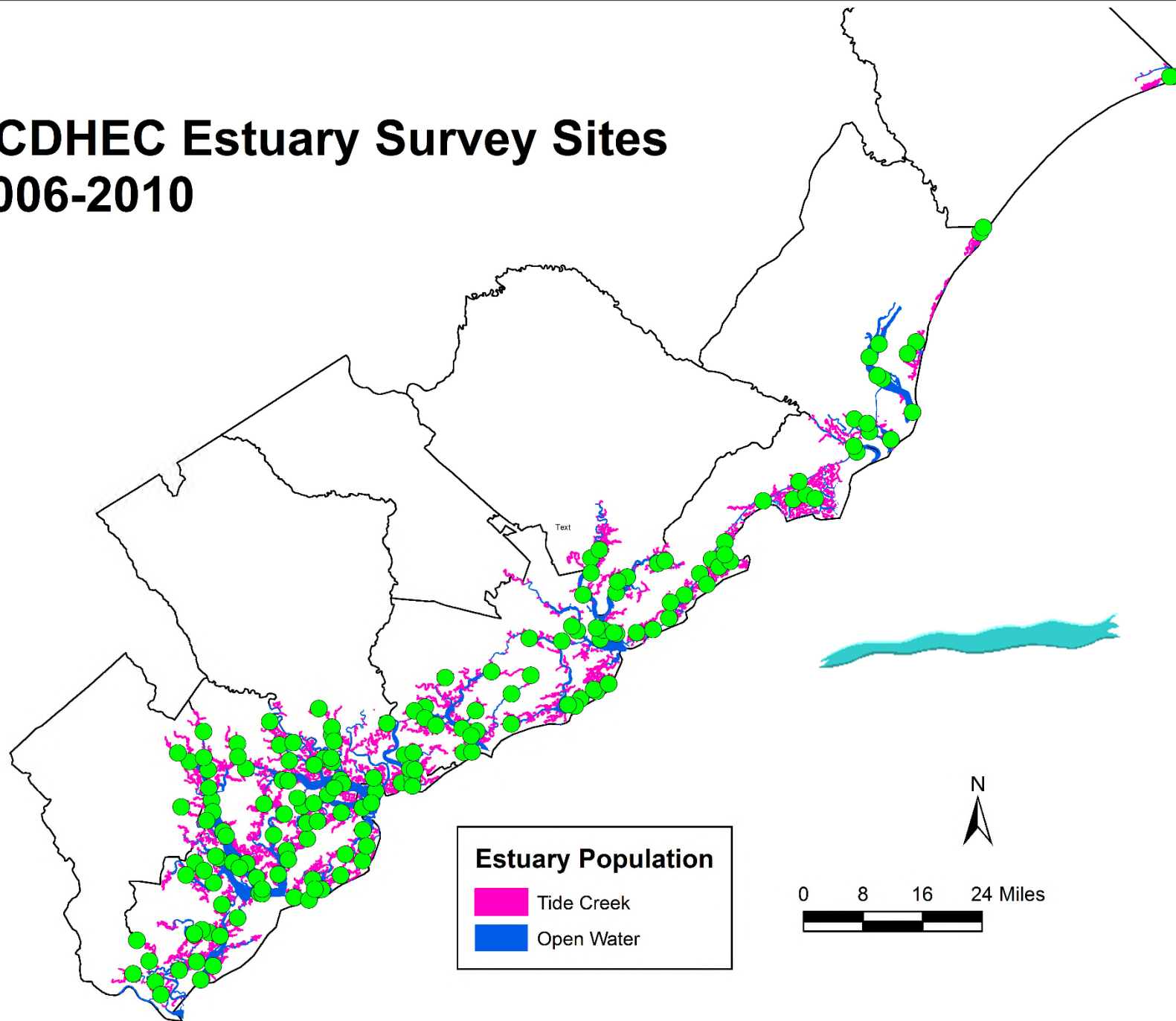
❖**Estuaries**

❖30 sites sampled monthly

– Two distinct strata:

• 15 Open water (> 100 m wide)

• 15 Tide Creeks (< 100 m wide)

Also part of the joint SCDHEC/SCDNR SCECAP program
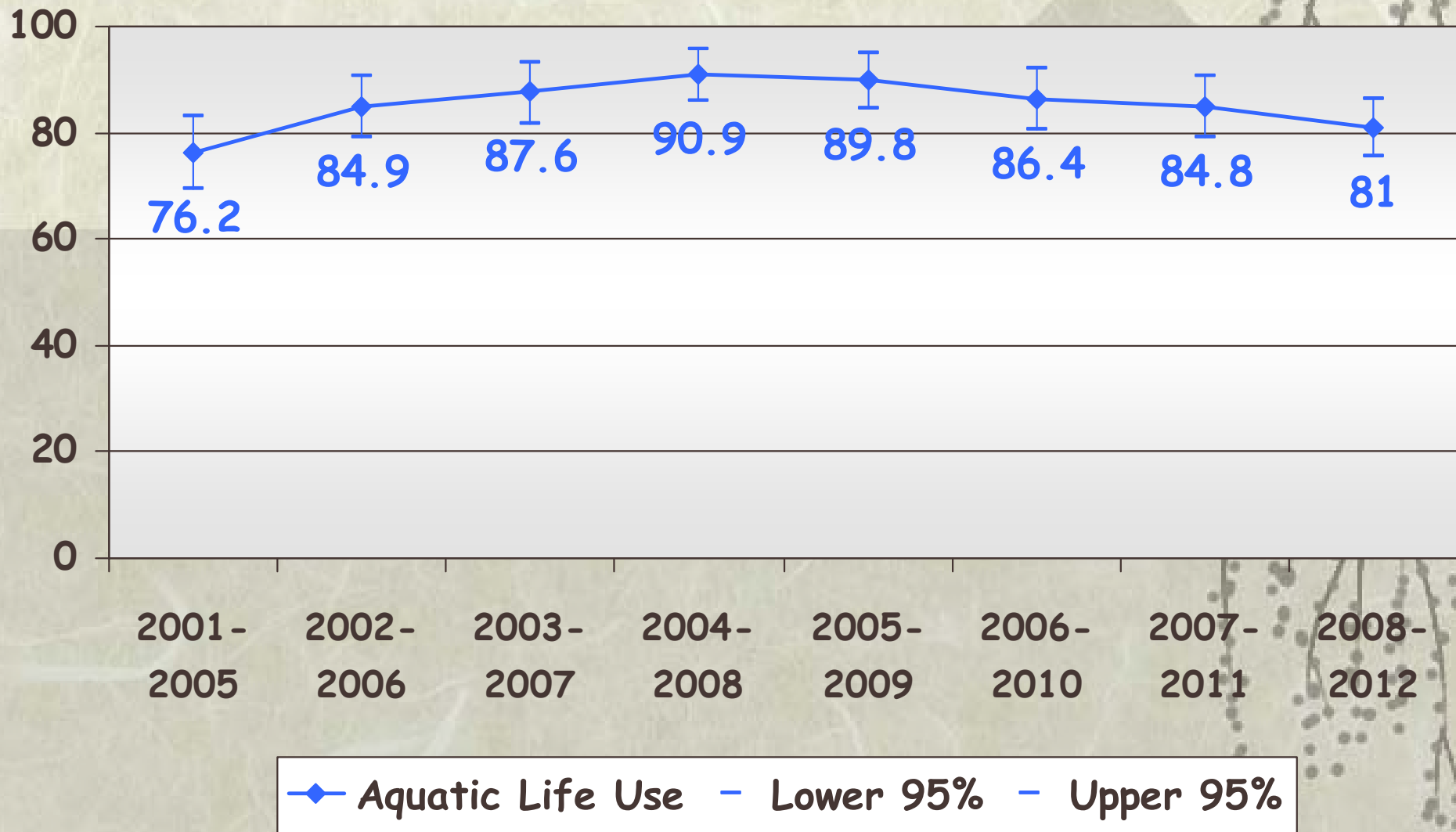
SCDHEC Estuary Survey Sites
2006-2010

Estuary Population

Tide Creek
Open Water

0   8   16   24 Miles

N

Estuaries

❖ **Statistical Survey Results**

– 150 water quality monitoring sites per 5-Year assessment period

– 289 square miles in the estuarine sampling design frame

Assessment Period	N Sites	Estimated Resource Size (Square Miles)
2001-2005	150	289.1
2002-2006	150	289.1
2003-2007	150	289.1
2004-2008	150	289.1
2005-2009	150	289.1
2006-2010	150	289.1
2007-2011	150	289.1
2008-2012	149	289.1

Estuaries – Aquatic Life Use
Fully Supporting - Rolling 5 Years

Chart showing Aquatic Life Use fully supporting percentages with upper and lower 95% confidence intervals across rolling 5-year periods:

- 2001-2005: 76.2
- 2002-2006: 84.9
- 2003-2007: 87.6
- 2004-2008: 90.9
- 2005-2009: 89.8
- 2006-2010: 86.4
- 2007-2011: 84.8
- 2008-2012: 81

Legend: ◆ Aquatic Life Use — Lower 95% — Upper 95%

Estuaries – Recreational Use
Fully Supporting - Rolling 5 Years

Chart values:

Period	Recreational Use
2001-2005	99.3
2002-2006	99.1
2003-2007	98.9
2004-2008	98
2005-2009	96.7
2006-2010	97.1
2007-2011	96.2
2008-2012	95.7

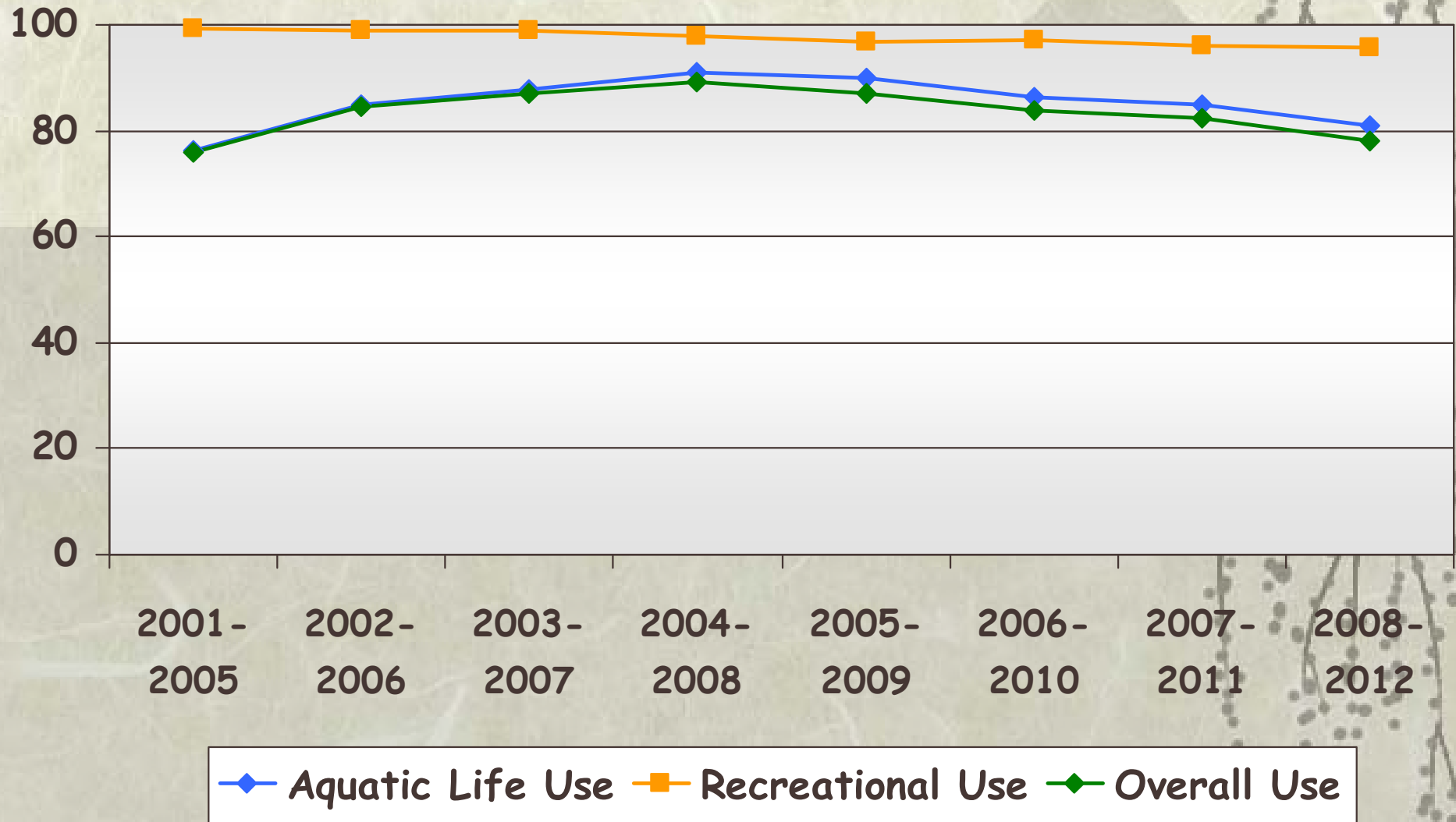Legend: ■ Recreational Use — Lower 95% — Upper 95%
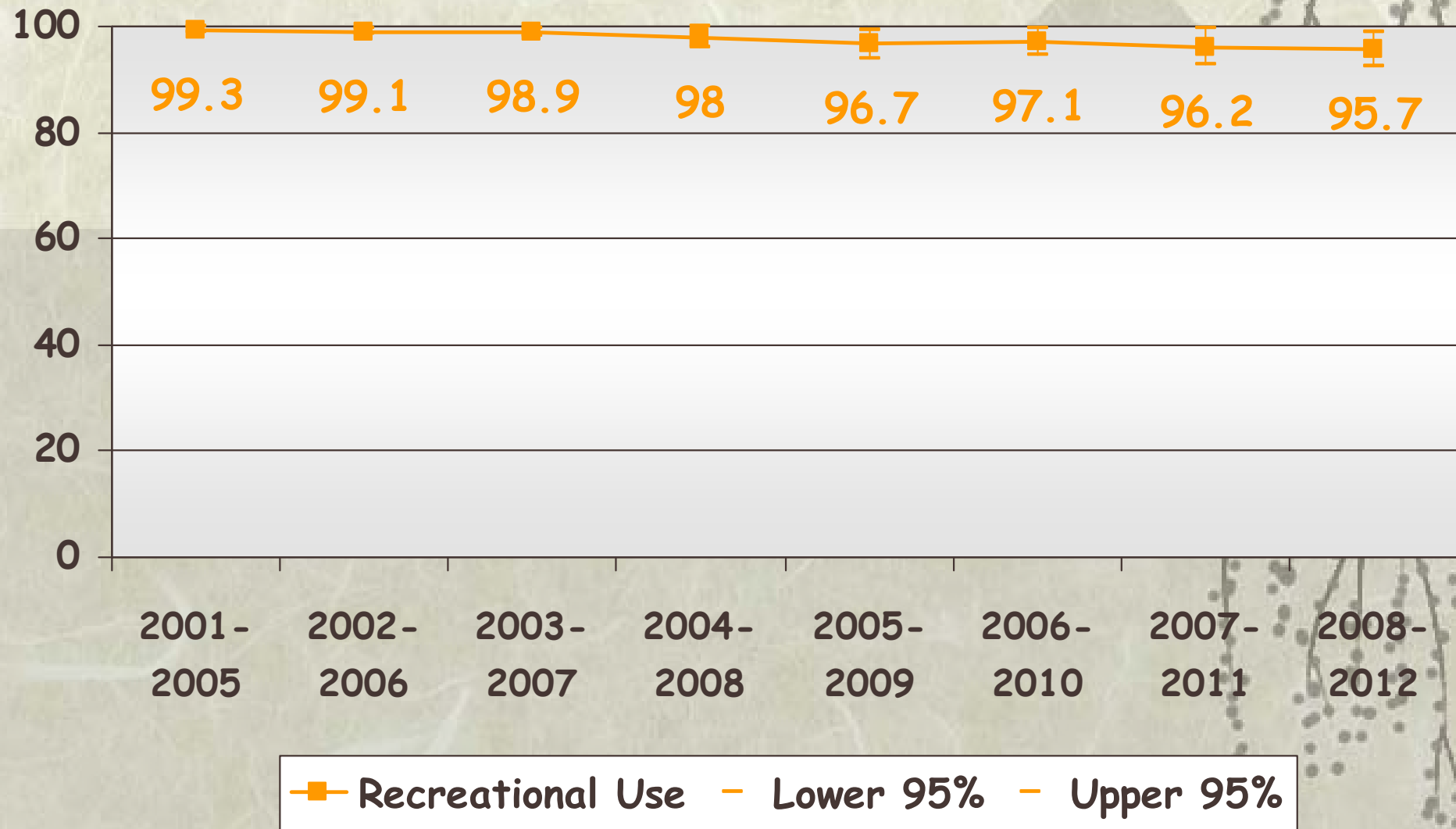
Estuaries – Overall Use
Fully Supporting - Rolling 5 Years
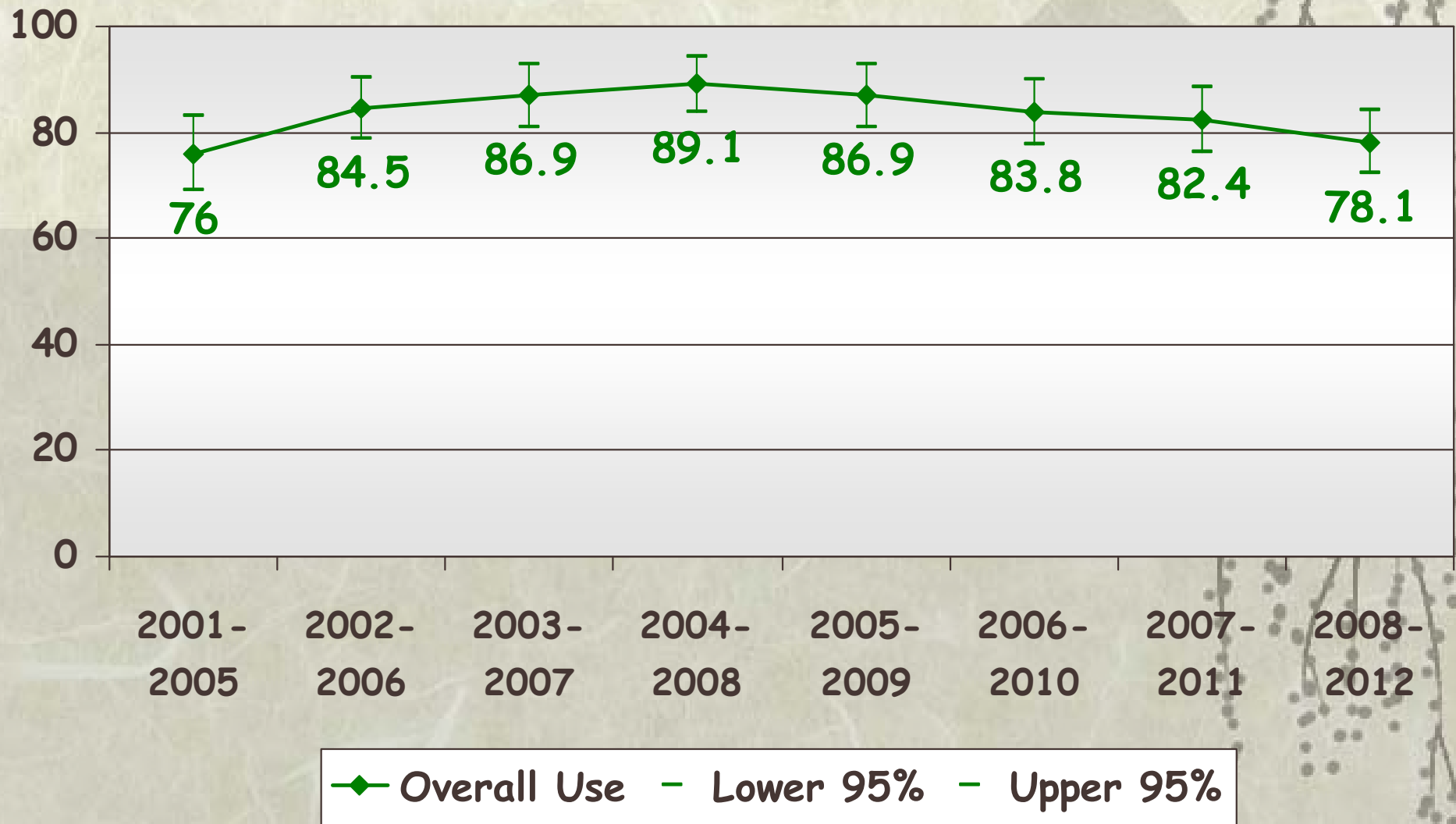
Estuaries – Summary
Fully Supporting - Rolling 5 Years

Estuaries – Top Causes of Aquatic Life Use Impairment

❖ Dissolved Oxygen and Turbidity are among the top 3 in all assessment periods

❖ Copper and Zinc were among the top 4 prior to the 2004-2008 period

❖ For 2004-08, 05-09, 06-10, and 07-11 Dissolved Oxygen and Turbidity were the only causes of impairment
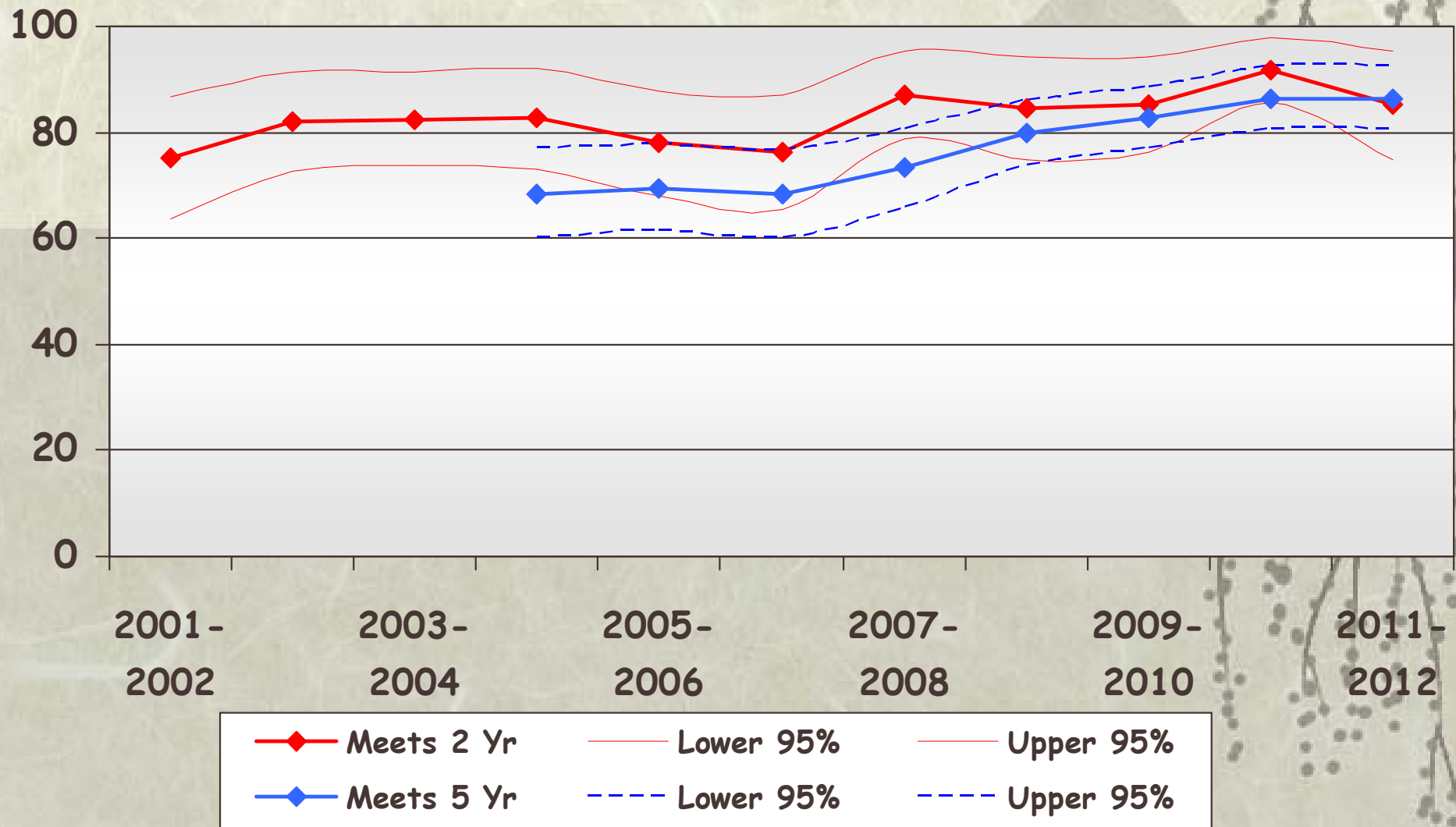
That's All Folks!

Any Questions?
Discussion?

http://www.epa.gov/nheerl/arm/designpages/monitdesign/monitoring_design_info.htm

or

go to EPA.gov and search for
"Aquatic Resource Monitoring"
and then select
Design & Analysis from the list

Streams – Aquatic Life Use
Fully Supporting - Rolling 5 Years

Statistical Survey Component

❖ **Great deal of pressure from EPA for state-scale statistically-valid survey of water condition**
  - We started around 2000
  - Line-item in §106 grant work plan since FY06
  - In 2008 EPA required certification of state-scale statistically-valid survey implementation
    • Intent was to make it a §106 grant requirement
    • With funding contingent on it
  - Specifically referenced and emphasized in the 2009 Integrated Reporting guidance memo

Important Considerations

❖ Is it a permanent, perennial feature?

❖ Logistics of access to sites

– Can the exact point selected be safely accessed?

- Reasonable walking distance from parking
- Reasonable distance from public boat ramp
- Sample holding-time constraints

Important Considerations

❖ If there is no acceptable access to the exact point, can it be moved to a **safely** accessible point that still represents the **same water quality**?

- No intervening "significant" tributary streams
- No changes in dominant land use practices
- No intervening point source discharges
- Additional considerations previously mentioned